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Abstract

Interdisciplinary and participatory approaches are necessary to address the complex challenges that climate change presents in various sectors, particularly energy, agriculture, and food production. In this paper, the methodology and results of the IntelComp Living Lab on Climate Change (LLoCC) in Greece, which was established as part of the IntelComp project and funded by the EU's Horizon 2020 programme, are presented. The LLoCC endeavours to facilitate evidence-based policymaking by employing artificial intelligence tools that analyse vast quantities of science, technology, and innovation (STI) data, utilising a Living Labs methodology that is rooted in real-world, user-driven co-creation. The study provides a comprehensive account of the stakeholder mapping and engagement process, the seminars that were conducted in the energy and agri-food sectors, and the iterative feedback that was employed to improve the STI Viewer and STI Participation Portal tools. The identification of priority policy concerns, sectoral innovation trends, and evaluation indicators, as well as insights on transparency, usability, and trust in data, are among the key outputs. The LLoCC demonstrates a collaborative model for aligning digital innovation tools with national climate policy requirements, supporting the work of Greece's High-Level Committee for Climate Change, by emphasising openness, empowerment, continuity, and practical relevance.

Key words: Climate Change, Living Labs, Artificial Intelligence for Policy, Stakeholder Engagement, Energy and Agri-Food Sectors

1. Introduction

Climate Change is a phenomenon that knows no national or regional limits. Its effects can be seen in both the natural and human spectra, such as human health, agriculture and food, forest fires, alterations in ocean salinity, etc. On the one hand, human activities radically affect the progress of climate change, and on the other hand, climate change progresses quickly, resulting in the need for climate adaptation and climate change mitigation measures. Considering the broad range of inputs, one should have to holistically develop a platform that will aid in making related to climate change adaptation. IntelComp, a Horizon 2020 Innovation Action project, aimed at building a platform that can analyse large volumes of textual data using artificial intelligence services, adopting a Living Labs methodology. IntelComp's LL is in close alignment with the definition provided by Schaffers & Turkama (2012): *"a collaborative innovation environment that facilitates research, development, and experimentation with product and service innovations in real-world contexts, facilitated by specific methodologies, tools, and structured innovation projects."* It engaged with stakeholder groups, *public administrations,* and *policy-makers*, as well as *civil society organisations*, *academia*, or *industry organisations*, to co-design and co-create IntelComp tools and services and validate the resulting platform through the co-creation of Science, Technology, and Innovation (STI) policies in three different domains: artificial intelligence, climate change and health, for specific use cases of the IntelComp tools and services. This study focuses on the IntelComp *Living Lab on Climate Change (LLoCC), seeking to address three research questions:*

a. *How can the design of supportive instruments such as IntelComp be informed by the principles, guidelines, and needs that policymakers have when developing climate-related energy and agrifood policies?*
b. *How can the iterative development of IntelComp tools be guided and early feedback validated through stakeholder engagement through trials and demonstrations?*
c. *What are the priority areas for the expansion of IntelComp tools, and how can user-driven requirements be effectively implemented into their ongoing development?*

This study captures the main results and activities of the LL on Climate Change. It starts with this introduction to provide the background and plan at the outset of the LL activities. Following the methodology that each IntelComp LL followed and tailored to their purposes, the main part of the report comprises the key results in terms of LL activities, as well as implications on the thematic domain of the LL and the technical development of the IntelComp tools. The fifth part shows the results of the Energy and Agrifood workshops, as well as the development and validation of the survey for the STI Participation Portal. The final part of the deliverable comprises the overall conclusion of the LL on Climate Change.

2. Methodology

Determining exactly what a Living Lab is can be challenging because there are many—sometimes competing—definitions (Compagnucci et al. 2021). There are several key characteristics that are mentioned in most definitions, namely the relation to real-life environments and the focus on stakeholders and on collaborative activities such as validation, experimentation, or testing—sometimes, these are part of a co-creation approach. Another important characteristic is that LLs are facilitated, not managed, i.e., the team behind an LL has no authority over the lab's participants (Westerlund & Leminen 2011). Sustainability is yet another characteristic that is often crucial (Leminen et al. 2016). As a work definition, IntelComp's understanding of LL largely matches the definition offered by Schaffers & Turkama, (2012): *"A living lab provides a setting for collaborative innovation by offering a collaborative platform for research, development, and experimentation with product and service innovations in real-life contexts, based on specific methodologies and tools, and implemented through concrete innovation projects and community-building activities."*

IntelComp largely follows the general approach of a Living Lab but adapts it to fit the specific context and needs of the project. This includes aligning with its broader policy ecosystem, which—as illustrated in Figure 1 —encompasses the domains of artificial intelligence, cancer, and climate change. The IntelComp LL is guided by four key principles. First, openness and transparency, ensuring inclusive participation from diverse stakeholders and clear communication about goals, outcomes, limitations, and expectations. Second, empowerment, by valuing and integrating participants' inputs, enabling meaningful engagement in LL activities, and supporting stakeholders in addressing their policy-related questions. Third, continuity, through ongoing mutual learning and sustained relationship-building among participants. Finally, practical relevance, by ensuring that all activities, outputs, and results are directly applicable to participants' real-world contexts, while also informing the development and impact of IntelComp itself (Koundouri et al. 2024). While the policy ecosystem provides context, the building blocks of the IntelComp Living Lab are represented by seven key elements. These key elements comprise the goals, specific policy questions and data sources, the stakeholder dimension (mapping, recruitment, engagement), the co-development of tools, the implementation roadmap, and the monitoring of the LL implementation (Figure 1).

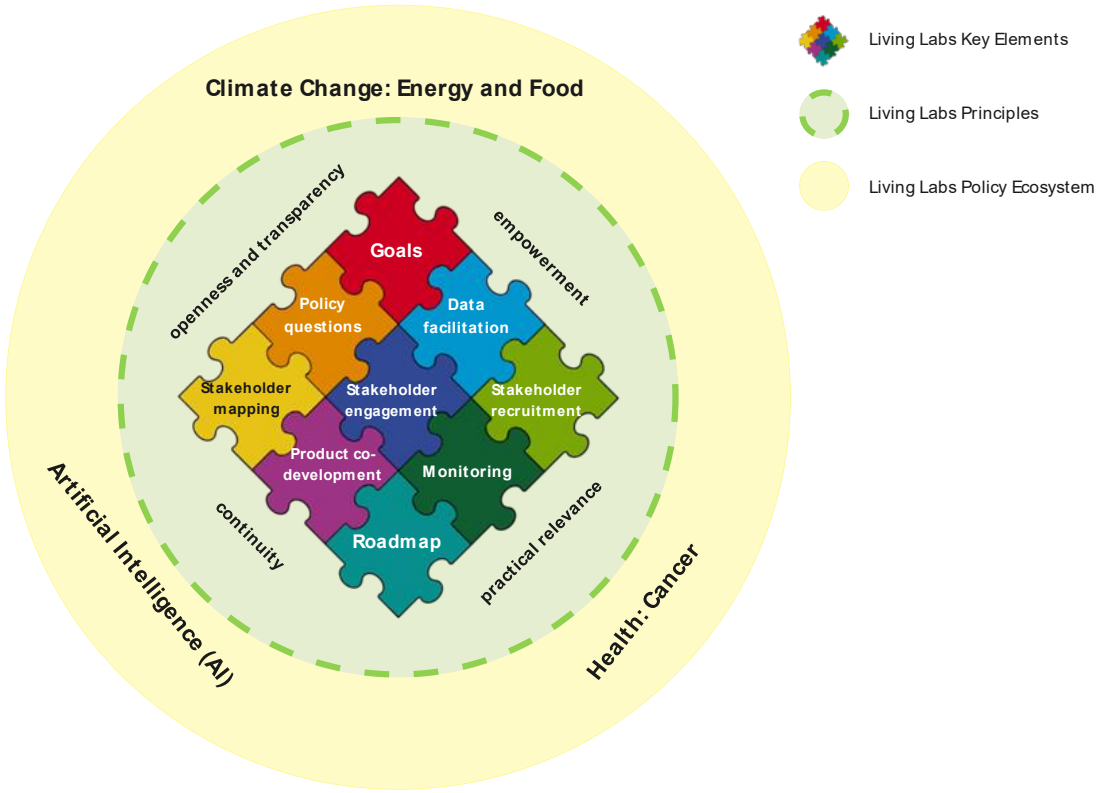


Figure 1 - Key elements and principles of living labs

The methodology used in tool co-creation is known as a design thinking approach and aims to understand and analyze the high-level needs (datasets and tools) of public administrators (PAs) and various stakeholders (citizens, academia, and industry), as well as to implement the policy co-creation model. The use case of this LL is Greece, which is also supporting the Prime Minister's High-Level Committee for Climate Change. Based on the Living Labs classification of Leminen et al. (2012), there are four types of LLs, namely, utilizer-driven, enabler-driven living labs, provider-driven and user-driven living labs (see Figure 2). The work performed in IntelComp Living Lab on Climate Change (LLoCC) falls under the utilizer-driven categorization, the focus of which is defined as "*developing and testing firm products and services*". Utilizers utilize living labs as a strategic tool to gather information on the users or user communities of their goods and services. In order to help the companies' long-term and short-term commercial development, user data on usage patterns, trends, and even rivals are gathered. The objective is to use assistance from people in the living lab's network to develop (or validate) new goods and services provided by the utilizer.

Characteristic	Type of Living Labs			
	Utilizer-driven	*Enabler-driven*	*Provider-driven*	*User-driven*
Purpose	Strategic R&D activity with preset objectives	Strategy development through action	Operations development through increased knowledge	Problem solving by collaborative accomplishments
Organization	Network forms around an utilizer, who organizes action for rapid knowledge results	Network forms around a region (regional development) or a funded project (e.g., public funding)	Network forms around a provider organization(s)	Network initiated by users lacks formal coordination mechanisms
Action	Utilizer guides information collection from the users and promotes knowledge creation that supports the achievement of preset goals	Information is collected and used together and knowledge is co-created in the network	Information is collected for immediate or postponed use; new knowledge is based on the information that provider gets from the others	Information is not collected formally and builds upon users' interests; knowledge is utilized in the network to help the user community
Outcomes	New knowledge for product and business development	Guided strategy change into a preferred direction	New knowledge supporting operations development	Solutions to users' everyday-life problems
Lifespan	Short	Short/medium/long	Short/medium/long	Long

Figure 2 - Characteristics of different types of living labs (Leminen et al. 2012)

2.1. LLoCC Policy Questions

LL on Climate Change (LLoCC) focuses on two important sectors: energy and agriculture/food. Given the broad and complex nature of climate change, addressing its challenges requires an interdisciplinary approach that integrates knowledge and methods from multiple fields. To support this, a set of policy-relevant questions has been systematically mapped with the aim of guiding both agenda-setting—by identifying priority areas for climate action—and evaluation—by assessing the effectiveness and direction of existing policies and initiatives. These questions are grounded in the methodology outlined in IntelComp Deliverable 1.2, which serves as a foundational reference for aligning data sources, indicators, and AI tools with policy needs (Markianidou et al. 2022). Table 1 and Table 2 present the shortlisted policy questions that were selected to be addressed within the LLoCC.

Table 1: Living Lab on Climate Change – Questions related to agenda-setting

Thematic Area	Key Agenda-Setting Questions
Corporate Sustainability	• Are companies adapting to sustainability trends? • How do they compare with competitors?

	• Who are the climate pioneers? • Are scale-ups leaving?
Startups & Innovation	• How many sustainability-focused startups were funded? • Are companies gaining international edge in climate technologies?
Finance	• How many issued Green Bonds? Is private funding used for climate action? • What national/EU resources exist?
Research & R&D Fields	• What are the top R&D areas by investment? • Where is comparative advantage improving? • Which scientific fields are growing (basic/applied)? • Emerging interdisciplinary fields?
Collaboration	• What are the cross-sector or cross-tech collaborations (esp. climate)?
Knowledge Diffusion	• Which diffusion channels work best? • What innovation hubs exist and operate nationally?
Policy Impact	• Which policy areas and societal challenges are addressed by research groups? • Content of environmental/climate policy papers? • Role of public opinion, media, and resistance factors?

Table 2: Living Lab on Climate–Change - Questions related to evaluation

Theme	Evaluation Questions
General	• How many patents were used in-house? • What were the royalties or returns (public/private) on climate-related investments? • What was the uptake of scientific results in patents? • How many start-ups were developed? • What innovations were produced by research centres (sustainability, socioeconomics, climate, blue economy/growth)? • How many jobs were created in renewable energy, maritime, fisheries, ports? • How many research activities focus on key climate topics? • How many publications were popularised in media? • How many research projects were funded across themes? • How many technicians were upskilled? • How many citations are linked to new technologies in building/urban planning?
Energy	• What are the latest trends in energy production? • What is the optimal energy mix and its influencing factors? • How many patents/licensed patents? • What is the reduction in energy poverty (in % and absolute)? • What innovations were developed by energy companies? • What are company sizes and tech used?

	• Who produces/supplies energy in Greece? • Which companies have R&D, applied for patents, or produced ESG reports? • What is the societal acceptance and legal framework for energy investments? • What are the economic/environmental incentives/restrictions? • What is the willingness to pay for greener energy? • How does the energy mix correlate with job creation? • What EU, national, and local policies exist on energy? • How does innovation relate to science mapping?
Agriculture/ **Food**	• How many patents were licensed or produced? • How many technicians were upskilled in sustainable fisheries/agriculture? • How many citations exist for new technologies? • How many patents were licensed or produced in maritime sectors? • What maritime innovations were developed? • How many people were upskilled in sustainable practices? • What are the citation counts for maritime and food production technologies? • How many citations are linked to forest/land use technologies?

2.2. Stakeholders mapping

Initially, we categorized the stakeholders by sector and category, compiling a comprehensive list of stakeholders relevant to the objectives of the Climate Change Living Labs, with one map for the Energy sector and another for the Agri-food sector. We employed the Quadruple Helix framework (Industry/Business, Civil Society/NGOs & Associations, Research/Academia, and Public Administration) to categorise the stakeholders. Subsequently, we refined the stakeholder mapping utilising the influence-interest matrix tool (see Figure 3**Error! Reference source not found.**), where 'Influence' denotes the extent of power and capacity a stakeholder possesses to effect change, while 'interest' indicates the likelihood of a stakeholder's participation in activities or initiatives pertinent to the case study's subject, which may arise from either a good or negative impact (Eden and Ackermann, 1998). An external expert validated the map after it was plotted.

This matrix facilitates the evaluation of each stakeholder's position about these two criteria to determine which subset of stakeholders is most appropriate for participation in the Living Lab. The primary group of stakeholders, from whom the LL members were selected, comprises those in the upper right quadrant (strong influence/high interest). This group is the heart of the LL, as these stakeholders not only are important for the goals of the project, but they exhibit the greatest interest in the work and are most inclined to engage in the research process.

Nevertheless, stakeholders from the upper left and lower right quadrants (i.e., high influence/low interest and low influence/high interest, respectively) are also taken into account, as the former encompasses stakeholders who may be pivotal in executing potential recommendations, while the latter comprises stakeholders possessing extensive local knowledge but typically lacking decision-making authority (often the under-represented voices). Nevertheless, engaging influential decision-makers is advantageous, as well as analyzing 'interest' facilitates the identification of stakeholders willing to invest time and effort in supporting the study (Brugha and Varvasovszky, 2000; Mendelow, 1981).

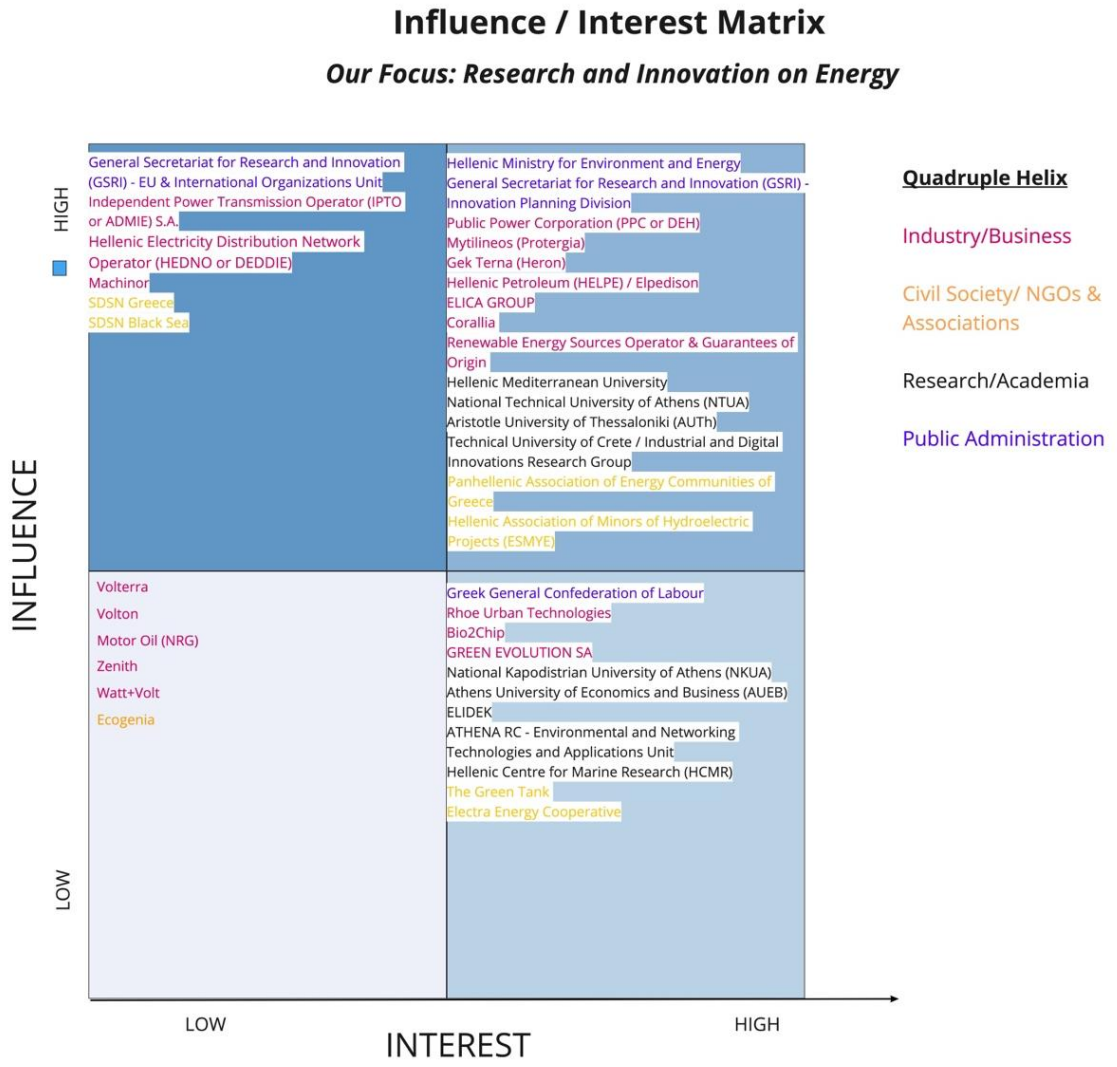


Figure 3 - Living Lab Climate Change: influence/interest matrix for the Energy sector. The stakeholders invited to the LLoCC, pertaining to the energy sector, are indicated in white.

2.3. Workshops design and delivery

In total, four workshops were designed and realised under the IntelComp Living Lab on Climate Change. Between December 2022 and November 2023, four Living Lab workshops were conducted focussing on Energy and Agri-food to identify the gaps and requirements of diverse stakeholder groups from the outset, ensuring their considerations were integrated into the development of the IntelComp platform. Subsequently, two training workshops were conducted—one focused on energy and the other on Agri-food—during the IntelComp Info Day in Athens on 20 November 2023. The objective was to assess and validate new solutions and services offered by the IntelComp platform, enabling users to engage in technical testing within a (semi)realistic usage context.

Figure 4 - Outline of LLoCC Workshops

+++ sti viewer

All four workshops were conducted online and comprised three primary activities: (a) an energiser, (b) a brief presentation of the project followed by a live demonstration on the STI Viewer, varying in scale based on the tool's development stage, and (c) a discussion focused on enhancing the STI Viewer tool, which was in the demonstration phase. Their aim was to acquaint stakeholders from industry and academia as well as policy officers and analysts with the project ambition and the STI Viewer capabilities.

3. Results

3.1. LLoCC—Energy Sector

As part of the Climate Change Living Lab, two online workshops were held in December 2022 and March 2023 regarding the energy sector, aiming to introduce the project to stakeholders, present them the STI Viewer, and register their feedback on the developed tool. The first workshop took place on the 8th of December 2022 and was titled "IntelComp STI Viewer tool for Academia & Industry". Its goal was to familiarise participants from the industry and academia with the STI Viewer. After a brief warm-up activity, participants gathered to discuss their concerns about the energy transition. They articulated their requirements and aspirations, highlighting the functionalities they deemed instrumental in their day-to-day endeavours of providing policy recommendations and monitoring new technologies. Afterwards, they were introduced to the STI Viewer and were asked to provide feedback and offer suggestions for incorporating the STI Viewer into their work. Participants included a leading company in electricity production and supply (Elpedison), a certified social cooperative that supports the transition to a democratic, efficient and sustainable energy system (Electra Energy Cooperative), the RES market operator in Greece (DAPEEP), the Hellenic Foundation for Research & Innocation (HFRI) and the Hellenic Centre for Marine Research. Considering that participants were from Greece, the workshop was held exclusively in Greek.

Firstly, the energiser provided the opportunity to participants to shortly introduce themselves and their organisation. Next, a short presentation of the project and the goals of the workshop took place and then participants had the opportunity to discuss their concerns regarding the energy transition, demonstrate their needs and demands, and present what would be helpful in their day-to-day work in policy advice and new technology monitoring. To do so, participants were given some indicative starting questions such as:

- How is your organization leading the energy transition?
- What is needed to make the energy transition happen?
- What information is missing or complicated?
- What would make your job easier and faster?

Afterwards, Dr. Grypari demonstrated the –then – developed version of the STI Viewer with a short presentation of its scope. Next, participants were asked to provide their ideas how they might use and incorporate the STI Viewer into their work. The lively conversation revealed several ideas for how the tool could be improved. The discussion was guided by two indicative questions, if they would use the STI Viewer in their day-to-day activities and if so, how they imagined using it. During this activity, stakeholders highlighted the following:

- What do the legal texts (such as EUR-Lex) contain? How this could be captured in the KPIs?
- What policies have been set by the EU? and to what extent ELIDEK's programs respond to this?
- How the policy development affects technology, industry, R&D?
- How is the impact measured?
- What is being funded at what time?

Finally, after the presentation of the demo version of the STI Viewer, questions were raised on how the data are crawled and curated and which ESG reports are analysed, considering that the realisation of such tool requires big data and advanced ML techniques.

The second workshop was held on the 22nd of March 2023 under the title “Energy: Indicators, Trends, Publications and Innovation”, specifically aiming policy officers and policy analysts in Greece and EU. This workshop not only served as an introduction to the STI Viewer, but also as a direct channel of open communication between potential end-users and IntelComp. It was attended by representatives from the Ministry of Environment and Energy, the Greek General Confederation of Labour, the General Secretariat for Research and Innovation (GSRI), the Hellenic Mediterranean University, the Renewable Energy Sources Operator and Guarantees of Origin, the Green Tank and the Unit B6 of the Directorate-General for Research and Innovation of the European Commission.

A brochure was handed out before the workshop, including the Agenda, the STI Viewer goals and some graphs produced by an early version of the STI, as an introduction to the capabilities of the project. The purpose of the brochure was to better prepare the participants before the workshop and to allow them to study the exported suggestive graphs. There was a short version dedicated to each participant, to introduce their organisation and themselves, as well as answer the short, but meaningful question, “What does data mean for you?”. Answers included: “protected”, “open”, “essential”, “exciting nightmare”, “reliable”, “powerful”, “truthful”, “robust”, “important”.

Afterwards, participants were informed, once again, that the workshop aimed to introduce them to the STI Viewer and to validate and improve the tool based on their needs. The STI Viewer was demonstrated by Dr. Grypari and participants were provided some time to re-read the booklet and to focus on the suggestive graphs derived from the –then developed- version of the STI Viewer. Both

workshops were held online through Zoom, while the collaborative platform Miro was used to visually present the needed information and register users' feedback.

In both workshops, participants were engaged and interested in the STI Viewer tool. This was expressed directly via commenting on the tool and indirectly, via openly discussing ways of how the tool could be utilised, as well as the importance of tracking innovation impact.

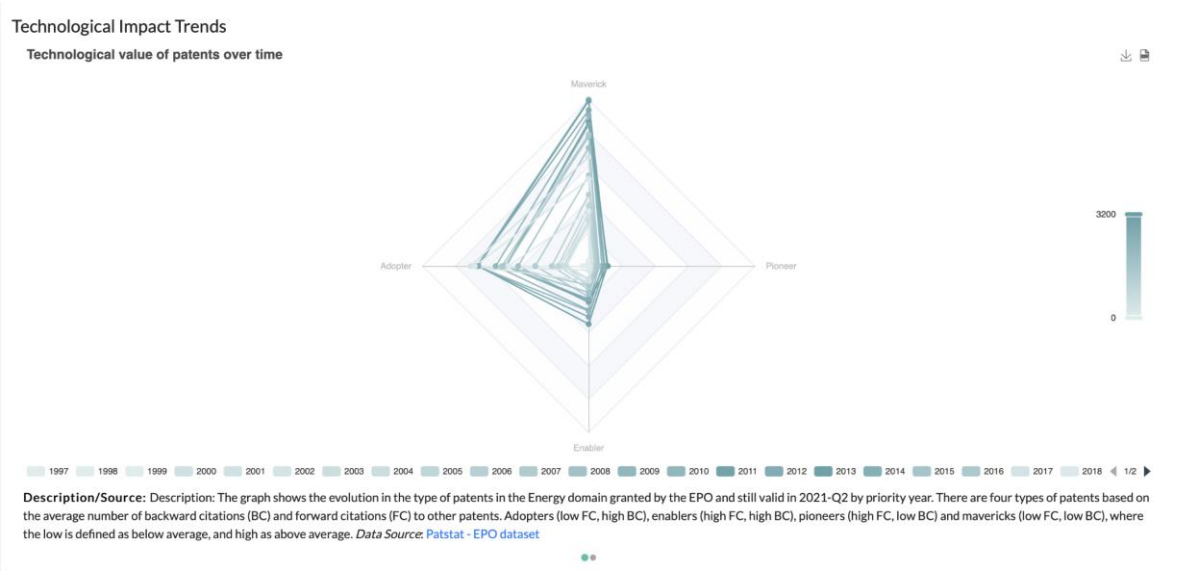
In particular, participants recognised, that measuring impact is a complex challenge, but STI Viewer provides a potential to identify correlations between different types of innovation and their impact on society. As a matter of fact, Energy Transition, which is much needed, is a complex interdisciplinary matter that requires dedication and lots of work from both the public and the private sector. A tool as STI Viewer could potentially benefit policy makers in understanding what is produced at a research level and what is adopted in the end. It could potentially help bridging the gap between research/innovation and activities.

Several questions were raised regarding the data sources and the data sets that are used to produce the final graphs seen in the STI Viewer. Specifically, participants were eager to know if the EUR-Lex databased was used and which indicators were utilised to measure the impact of research adoption. Furthermore, they asked about the ESG reports of major companies and how they are integrated in the work of the project. Questions were also asked about how the links between different publications are created and how patents are registered and crawled.

They were also impressed with the potential of Natural Language Processing and the ability to analyse text of scientific publications and patents, as keywords and phrases identified could indicate emerging trends. Furthermore, the need for more informed decisions about funding and innovations was highlighted. Thus, the participants saw the potential of IntelComp project and the STI Viewer to help policymakers identify areas of research and innovation that could/should be prioritised.

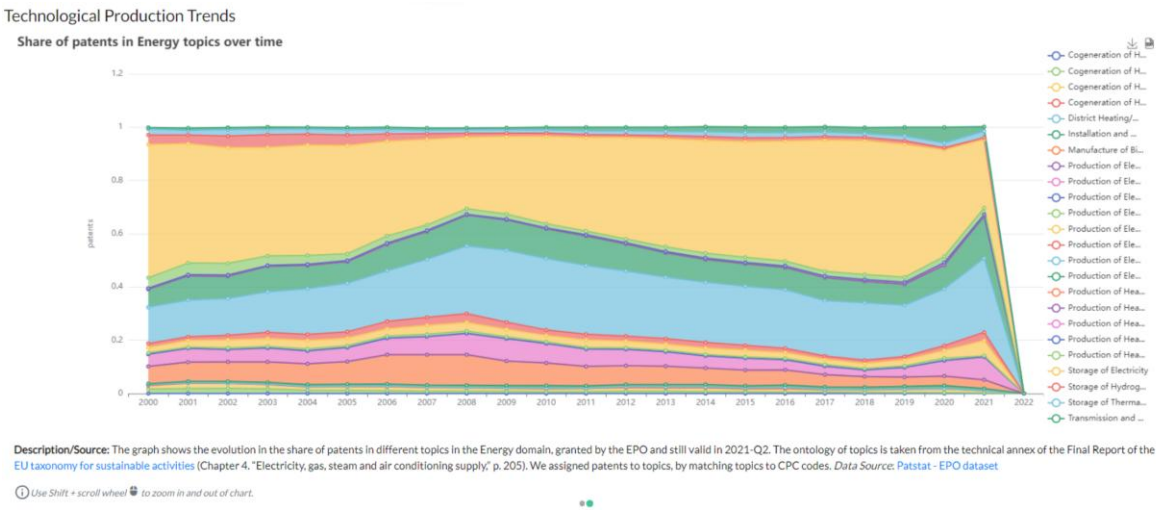
Especially during the 2nd workshop, participants were able to have an even closer look to the STI Viewer.

Figure 5: STI Viewer, Domain: Climate, Geographic Coverage: EU, Category: Energy, Technological Impact Trends, Technological value of patents over time. Source: STI Viewer.



In Figure 5, presented to the participants, one can see the evolution in the type of patents in the Energy domain granted by the EPO and that are still valid in 2021-Q2. The results are presented based on the average number of backward citations (BC), forward citations (FC) to other patents, revealing were industry/research stands in terms of adopting patents (technologies), pioneering (high FC, low BC), enabling the developed patents (high FC, high BC) or observing (low FC, low BC).

Figure 6: STI Viewer, Domain: Climate, Geographic Coverage: EU, Category: Energy, Technological Production Trends, Share of patents in Energy topics over time. Source: STI Viewer



They were very interested in the developed STI Viewer, which is proved by the questions asked about how the links and references between different publications are created, how is information being classified, and which data sets are used in order to produce the suggested graphs.

The discussion emphasized the need for tailored data access for different user profiles, acknowledging that diverse end-users have varying expectations and require customized granularity in the presented information. Additionally, given the immense challenge of sustainable energy, capturing societal and community sentiment is crucial for comprehensive decision-making. It was also mentioned that, as challenging as it is, the users should be able to "construct a narrative from the visualisations" and identify the impact of different productions, whether they have led to any patterns, companies developing products on these insights and whether the public is engaged with these issues. The conversation underscored the importance of balancing comprehensive data presentation with clear storytelling allowing users to extract meaningful insights from the vast amount of information. Linking industry and research, could be made by linking patents to publications, a participant expressed, as a policy maker could eventually see if research is being adopted by the industry or not, and if research funding is towards the right direction.

Finally, participants made a few more suggestions that could further improve the STI Viewer tool:

- The ability to filter data by additional criteria, such as the type of research organisation or the funding source
- The ability to download the data behind the visualisations in a more user-friendly format, such as CSV or Excel
- The ability to create custom visualisations based on the user's specific needs
- The ability to integrate with other data sources, such as industry reports and market data
- A filter per country, that would allow cross-examination between countries and between countries and EU.

Part of the feedback was addressed by the technical teams in terms of content and end-user requests. For instance, a holistic approach was followed to cover science, technology and innovation, by including research analysis, patents examination (i.e share of patents over time) and ESG analysis, as well as Green Skills integration. Graphs are easily adjustable and downloadable in various formats, filters were added, while data and data sources are available. Community is mostly represented by the Participation Portal, another tool developed within the scope of the project, which is analysed below. Some suggestions, however, were not implemented, such as the ability to have side-by-side comparisons of the results at a country level and an EU level, as well as to have different granularity in the end product based on the user category.

Results relevant for the thematic agenda setting

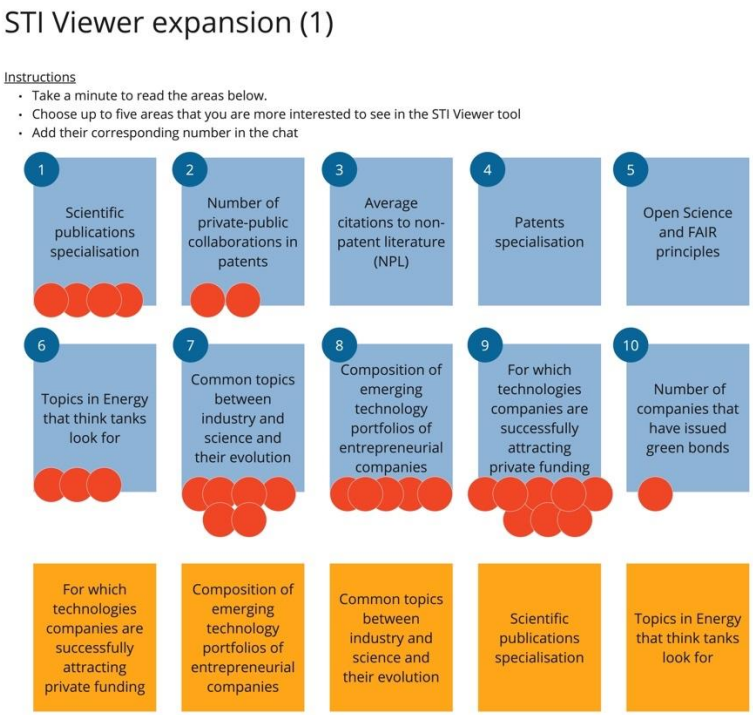
Participants did not only share their views on the STI Viewer, but also, expressed their considerations regarding Energy Transition and how this can take place considering economic, political, environmental, social, technological, and legal issues. The need for the expansion of the share RES have in the energy mix was highlighted, by several stakeholders, but with a different view. Those coming from community, believed that energy transition should indeed come from the expansion of RES but through the creation and support of existing and to-be-established energy communities. On the other hand, participants representing the industry, cared more on the numbers and to achieve the target of 60% RES in Greece by 2030. Major disagreements were also expressed about whether Natural Gas and Nuclear Energy should be considered RES or not or at least if they could be considered transitional energy sources (this was also a topic that was being discussed during December 2022 at a European Level). “In a just energy transition, Natural Gas does not have a place” a participant argued.

Furthermore, all stakeholders agreed that the Energy Transition should take place in a just and safe environment for the local communities and that all should work together bearing in mind society and not just economy. This could be materialised through including different energy sources in the energy mix and by promoting research on batteries and energy saving technologies, and by investing in battery deployment, that can make RES more competitive. All agreed that to make a just Energy Transition feasible, the need for upskilling and reskilling is eminent, suggesting that socio-economically the required skills should be recognised and programmes that aim at educating and training employees should be deployed.

During the 2nd workshop in June, the discussion focused on the STI Viewer expansion aiming to integrate more thematic areas for the agenda setting. Participants were asked to choose up to five areas, that they are more interested to see in the STI Viewer tool, using stickers and then elaborate on the most preferred topics. The thematic areas were identified during desk research, but are not part of the STI Viewer (i.e. number of companies that have issued green bonds).

Based on the results, participants expressed a keen interest in exploring which technologies are currently attracting significant private investments and the composition of emerging technology portfolios of entrepreneurial companies. Additionally, they sought insights into the common ground between industry and academia and how this relationship has evolved over time. Furthermore, they were eager to gain a better understanding of the topics Energy Think Tanks are currently prioritising, and they requested a focus on scientific publications within the context of the energy sector.

Figure 7: STI Viewer Expansion exercise results, 22.03.2023. Stickers were used to have a heat map on what participants would like to see in the STI Viewer



In both workshops, the importance of society for Energy Transition was highlighted. Participants expressed that without considering the public, one cannot proceed in drafting just policies. This proved the need of establishing a tool that allows the indirect communication between policy makers and communities.

3.2. LLoCC & the Agri-food Sector

Two online workshops on the Agri-food sector, part of the Climate Change Living Lab, were organised between June and October 2023, aiming to reveal stakeholders' preferences and feedback regarding the development of the STI Viewer. The title of these workshops was "**Indicators, Trends, Publications and Innovation".** In both workshops, (**6th of June and 5th of October 2023**) stakeholders were presented the goals of IntelComp project and a demo of the STI Viewer tool, focusing on the graphs that were available at this time on the Climate Domain, for the Agri-food sector in the EU, e.g., Scientific Impact and Scientific Production and Collaborations (Science) and Technological Production trends, impact, and origins (Technology). Then, they were invited to participate in a moderated discussion on the usefulness of the existing indicators and future development of the STI Viewer tool.

The workshops were attended by selected stakeholders who work on the Agri-food Science-Technology-Innovation triangle in Greece and EU. In detail the participants were from: (a) *policy sector*, e.g. the General Secretariat for Research and Innovation, Ministry of Development and OECD -Directorate of Science, Technology and Innovation, Science Technology Policy Division (EU); (b) *academia (research and education)*, such as from the Hellenic Mediterranean University (Greece), Hellenic Agricultural Organisation - Soil and Water Resources Institute (Greece), American Farm School (Greece), Hellenic Agricultural Organization "DEMETER" (Greece), ELIDEK - HFRI Research Department (Greece), ATHENA RC (Greece), Athens University of Economics and Business (Greece), NTT DATA (Spain), Spanish Foundation for Science and Technology (Spain) and University of Pisa (Italy); and (c) *NGOs and Civil Society*, such as from the Foodscale Hub (Greece), SDSN Greece (Greece) and SDSN Black Sea (Greece).

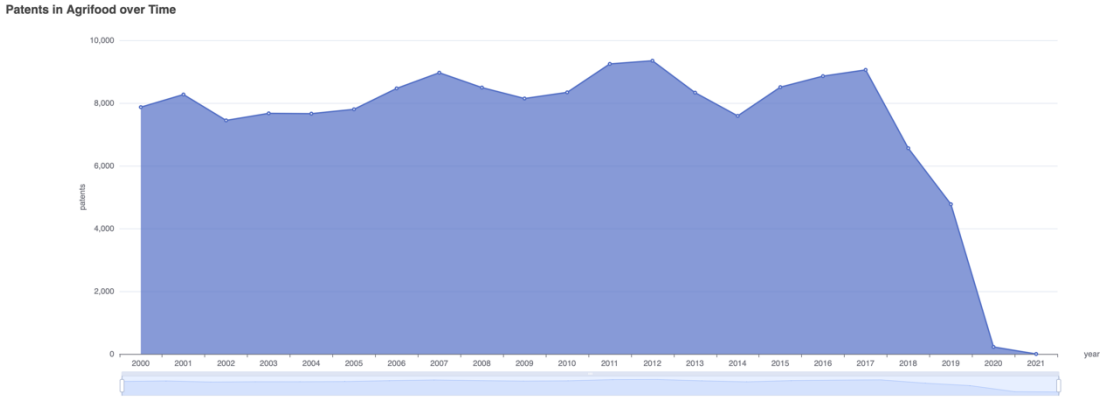
Participants/users' experience regarding interactions with IntelComp / tools

Participants were given a booklet to read before the workshop, which had the agenda, the STI Viewer goals, and some suggestive graphs. This booklet was handed to them so that they could be prepared before the workshop began (see **Error! Reference source not found.**). During the workshop, after Dr. Grypari demonstrated the current version of the STI Viewer, participants were provided some time to go through the graphs (using the booklets) from the "work in progress" STI Viewer and think about how they would use them in their day-to-day work and comment what could be improved. The output of this workshop helped development teams prioritise and update some functionalities. Indicatively, regarding the overall usability of the tool, they made the following comments:

- There is a need for more filters that would provide more clarity. Specifically, they suggested filters that were based on climatic zones, regions, certain nations, or even crops. If you want to find anything that interests you, you can't physically go through every publication. It is necessary to limit it down to a very specific point and identify exactly what is intriguing. It would be also helpful to have a filter to locate the most recent data for categorization or spatial extensification.
- They also requested the inclusion of time ranges, as well as the ability to export and distribute the results.

They also provided feedback regarding specific areas/graphs. During the workshop in June 2023, the stakeholders shared their thoughts regarding the STI Viewer graph on *Technological Production Trends* with title: "*Patents in Agri-food over time*" (see Figure 8), where they made the observation that the graphs are pertinent; nevertheless, it was not clear what is the exact focus of the patents. The emphasized that it is necessary to have a second level, such as anything that can restrict the search material and make it more accessible (for instance, industrial property regulations). Additionally, it would be of great assistance to determine which patents have already been commercialised (and who has invested in them), while they indicated that it is necessary to determine what is currently available on the market and is not just protected, but also where it was commercialised.

Figure 8: STI Viewer, Domain: Climate, Geographic Coverage: EU, Category: Agri-food, Technology, Technological Production Trends, Patents in Agri-food over time. Source: STI Viewer



Part of this feedback was addressed by the technical teams. For example, they added a graph with the share of patents over time and the number of patents per IPC (International Patent Classification) code in the Agri-food domain (see Figure 9 and Figure 10). However, the general abovementioned comments were not taken into consideration by the technical teams.

Figure 9: STI Viewer, Domain: Climate, Geographic Coverage: EU, Category: Agri-food, Technology, Technological Production Trends, Share of Patents in Agri-food Topics over time. Source: STI Viewer

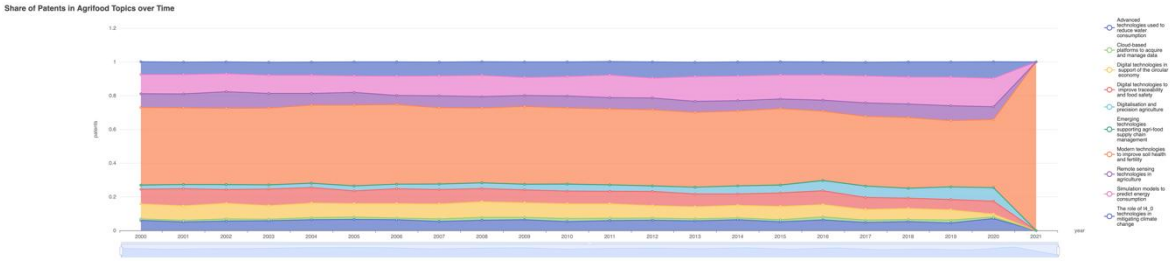
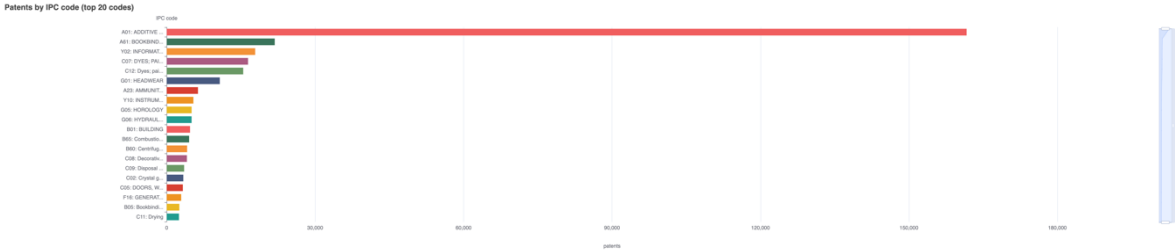


Figure 10: STI Viewer, Domain: Climate, Geographic Coverage: EU, Category: Agri-food, Technology, Technological Production Trends, Patents by IPC code. Source: STI Viewer



Additionally, during the workshop in October, stakeholders mentioned that in regard to the *patents section*, it is necessary to require all nations to develop strategies for specialisation. The graphs provide one dimension that relates to scientific production and institution-related activities. The essence of the matter is to integrate what is happening in terms of entrepreneurship. IntelComp technical teams had already started working on an industry analysis that is comparable to the one conducted in science, integrating indicators regarding the companies that are the most inventive in terms of their trademarks and the matters they address. However, stakeholders requested indicators that would show the comparative advantages of the industries in relation to the Smart Specialisation Strategies (https://gsri.gov.gr/ethniki-stratigiki-exypnis-exeidikefsis-2021-2027/), i.e., the comparative advantage will not be based on the quantity and quality of the publications in any given discipline, but rather on the entrepreneurial prowess, which aims to enhance through research endeavours. For example, there are some documents pertaining to the automobile; however, the automotive sector in Greece does not appear to be particularly developed; therefore, the nation would not invest in it. Thus, the industry section in the STI Viewer is a suitable starting point for someone who wishes to pursue further scientific knowledge and development.

In regard to the cutting-edge technologies designed to enhance the fertility and health of the soil, who could the farmers contact to seek collaboration? What is the definition of technologies? A more precise breakdown in the STI Viewer aiming to answer these questions would enhance the understanding and takeaways of the interested parties. Additionally, we need to know the matching of the Smart Specialisation Strategy priorities to the regional production outputs. E.g., If region of Crete makes for additional carobs and the STI Viewer has mapped the farmers who produce carobs, then a matchmaking could be achieved through the tool. In case, there is a demand for more carbos than what the region produces, farmers could get informed about this opportunity and trained regarding the demand in the particular region, including specific quantities and crops, so that they may be assisted in changing crops by certifying it, cultivating it appropriately, and capitalising on the funds that flow through it. Gradually, appropriate cooperation should be established.

Stakeholders were also asked regarding the transparency and trust on the data and if and how they would use them in their work. They said that in general it is a user-friendly visualization They highlighted that a section that includes the Sustainable Development Goals (SDGs) are important on

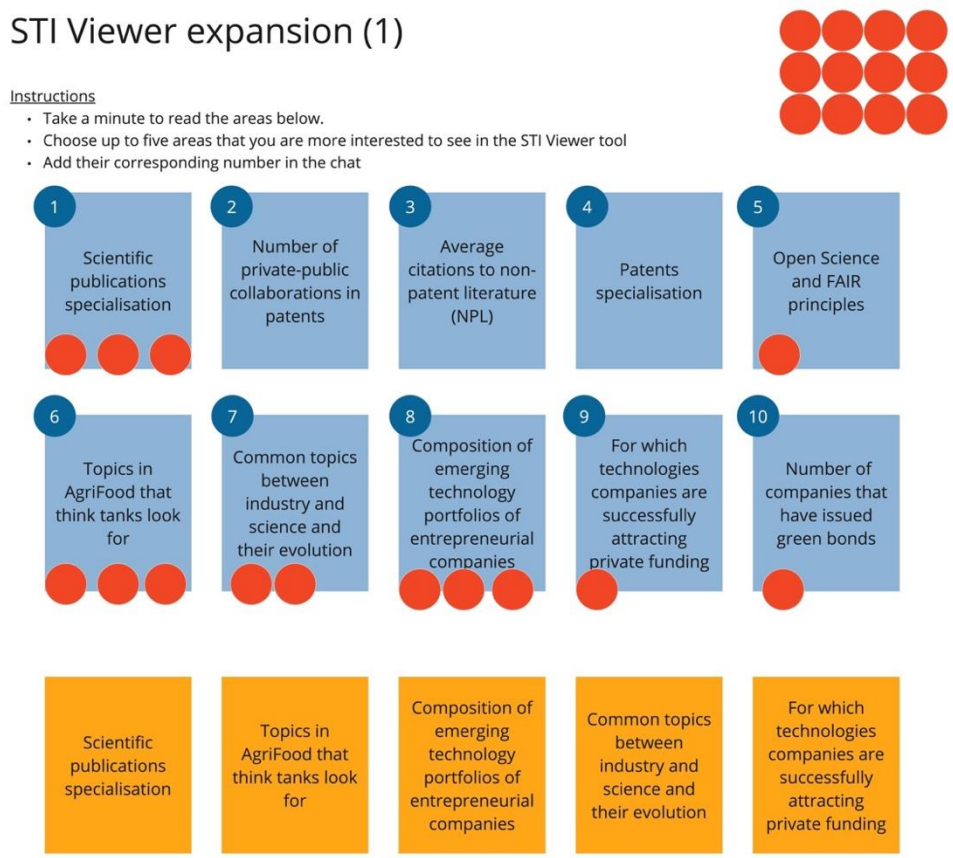
both the EU and international levels. The SDGs is yet another method for differentiating publications in a variety of subject areas. Therefore, they can also assist us in communicating in the same language, as an indicator that is applicable everywhere. Finally, they confirmed that the quantification and aggregation of the data would explain the reasons why certain decision have been taken on a top-down level.

Results relevant to the thematic agenda-setting

During the second phase of the workshop in June, the discussion focused on the STI Viewer expansion aiming to integrate more thematic areas for the agenda setting. Participants were asked to choose up to five areas, that they are more interested to see in the STI Viewer tool, such as *number of companies that have issued green bonds, open science and FAIR principles* etc (see Figure 11), using stickers and then elaborate on the most preferred topics. They identified the following areas:

- Scientific publications specialisation
- Topics in Agri-food that think tanks look for
- Composition of emerging technology portfolios of entrepreneurial companies
- Common topics between industry and science and their evolution
- For which technologies companies are successfully attracting private funding

Figure 11: STI Viewer Expansion exercise results, 06.06.2023. Stickers were used to have a heat map on what participants would like to see in the STI Viewer



After that, they were asked how they might implement these indicators into their daily work, if they have any additional suggestions for the tool and if such an analysis concerning funded programmes, such as Horizon 2020, pique their interest. They discussed their indications for the expansion of the STI Viewer.

They highlighted that "Scientific publications specialisation" is an excellent predictor of what science will or will not accomplish. Thus, it is prudent to determine what private companies are planning to invest in and reach a consensus on that point. Already, it is a sustainable entity. This will also affect job creation, as jobs will follow when there are clear opportunities.

The market products coming from technologies would be an interesting outcome of the "Composition of emerging technology portfolios of entrepreneurial companies".

Regarding the "Topics in Agri-food that think tanks look for" would be interesting to be used in the research project, where we could know what the hottest topics are. Although society holds an opinion, it is not obligatory for it to do so on every matter (they lack the requisite expertise). It shall evaluate the outcomes. Its utility will elicit a favourable response. NGOs and think institutes do possess an understanding of societal requirements on occasion.

Most initiatives are centred on devising methods to establish sustainability. It is thus commendable to observe and advocate for this cause among policymakers. Thus, an indicator of the "Common topics between industry and science and their evolution" would bring significant value.

To discern that our trajectory is correct. Obtaining funding would indicate that we are proceeding in the correct direction. Consequently, it would be useful to have an indicator "For which technologies companies are successfully attracting private funding".

STI Participation Portal, Energy & Agri-food Sector

From April 2023, ARC developed the survey on climate change (see Annex 3) that would be integrated in the STI Viewer Participation Portal tool. The survey aimed to facilitate evidence-based policy making by providing STI policymakers with an understanding of public sentiments (rather than assisting in the development of the IntelComp tools). The target audience of the survey were representatives of NGOs, Cities, and Civil Society, in addition to Academic and Industrial Associations, who would be invited through personalised invitations to fill in the survey in the STI Participation Portal. While some survey questions are closed, others are based on the diagrams in the STI Viewer, which are incorporated into the survey. Thus, the focus of the survey were the 2 Climate Change areas, in which IntelComp STI Viewer and LL workshops were focused on, Energy and Agri-food. There were both general questions suitable for all individuals and tailored to particular non-governmental organisations. The questions raised, aimed to provide a brief profile of the questionee, give insights about the energy and/or the agrifood sector, and allow the questionee express their opinion regarding the end-results of the STI Viewer (graphs and data). The survey results will be integrated into the IntelComp platform, while through the STI Viewer, the survey responses will be transmitted directly to STI policymakers.

The survey was developed as follows:

- Part A: Demographics
- Part B: General
- Part C: Energy-related STI Policymaking (Renewable Energy, Energy efficiency, Nuclear Energy and Fossil Fuels)
- Part D: Agri-food-related STI Policymaking (Sustainable Food production, Sustainable Food processing & distribution, Sustainable Food consumption, Food loss and waste prevention).

The first draft of the survey was initially shared with the technical teams for feedback in May 2023 and explicitly presented at the technical meeting on 6th of July 2023, which took place at ATHENA RC. Further feedback from the IntelComp team was received by September 2023, while the questions were validated through 1:1 discussions with stakeholders on Agri-food and during the last LL workshop on 5th of October 2023. The last workshop, which took place on the 5th of October 2023, had a second goal of validating and improving the STI Participation Portal tool and thus, the survey related to STI policies based on stakeholder needs. Firstly, stakeholders were asked if the sub-categories used in the survey would fully cover the topic of Agri-food or if there was something important that had been omitted. Stakeholders confirmed that the sub-categories were indeed representative, as long as chemical companies were part of the value chain for the Agri-food sector).

Then, they were asked how the four sub-categories could provide solutions to STI-related challenges and how charts could assist with these challenges, such as if the survey could disclose information regarding a scientific challenge pertaining to food production. Participants answered that the figure that illustrates a decrease in the output of scientific articles may be explained by the fact that there were no programmed activities. Greece's scientific community is organised into programmes. This is because there are just a few patents. Due to the fact that no businessman would work on anything that only he would know about, there are not many academics who are concerned in preserving their intellectual property.

Although there are policies that promote sustainable development, the real economy lags behind. Right now, waste goes back to the producer, and the seller is not interested in waste and food loss. Thus, more effort and budget should be spent on implementation and monitoring. For instance, the Smart Specialisation Strategy aims to reduce the costs of manufacturing and inputs while avoiding a fight back. How can we achieve that? How can we prioritize these needs? If you travel to Patras, a Greek city, how is it possible to get Dutch tomatoes at a lower price than those that are grown in its neighbouring city? To what extent does food go missing? How much is total consumption of food? When it comes to sustainable food production, how much is the production? These types of questions should be addressed to the citizen groups aiming to understand why application of smart and sustainable practices can be enforced in the Agri-food sector.

They also highlighted the need for an intermediary mechanism that would transfer scientific research into practical and useful tools for the people across the Agri-food value chain, as well as the need to transform entire supply chains in order to advance sustainability. In regards to the funding programs, they suggested that for the recipient to be eligible to receive the funds from any programme, it is imperative that they have participated in a designated training session with quantifiable outcomes. Funding programs that aim to boost the agricultural sector in the country shall not focus on the financing schemes, rather use a more participatory approach, where the farmers would not only voice their concerns, but also get informed regarding environmental challenges, e.g., that some chemicals are carcinogenic and should be eliminated from the production process, and how to apply for funding for sustainable practices. In such participatory process, after being fully informed, farmers should be asked, whether they need support to purchase a new tractor or an innovative solution, e.g., sensors. Collective effort is required to unite the entire globe. In addition, sustainable practices they are suggested to have higher rate of funding (e.g. 70%) and less for conventional technologies, e.g. new trackers etc (e.g. 30%).

In summary, ARC discussed which questions were required in order to depict the goals of the STI Participation Portal, which was to give the chance to society to converse with policy makers, but also combine the STI Viewer and have it act as an open window between the two stakeholder categories (policy makers and society). In this framework, stakeholders raised concerns that should be taken into account in the survey regarding the Agri-food breakdown that should include aspects, such as the chemical industries, emissions, and retail; as well as that policy makers need to map where we stand today, provide motives to farmers (such as financial aid, specific trainings, connection with the

innovation and scientific community) for implementing sustainability practices, and to sellers (such as redefining the producer's responsibility) to avoid food loss.

STI Viewer & STI Participation portal demo & final feedback

On 20th of November 2023, the National Greece Info Day of the IntelComp project (https://intelcomp.eu/events/national-greece-info-day) took place in Athens, at the National Library of Greece - Cultural Center Stavros Niarchos Foundation. The conference centred on the role and impact of Science, Technology, and Innovation (STI) in facilitating national adaptation and management strategies for climate change impacts. The primary objective of this gathering was to convene a diverse range of stakeholders, including policy-maker representatives, industry experts, environmental and technological experts, and societal impact stakeholders. Their purpose was to engage in a comprehensive discussion regarding the latest developments in STI and the pressing concerns associated with energy sustainability and the agri-food production model in light of CC.

During the Info Day, ARC organised 2 workshops on Energy and Agri-food, demonstrating the IntelComp tools. It gave the chance to participants to familiarize with the STI Viewer and the STI Participation Portal. The workshops were attended by stakeholders coming from the public sector (General Secretariat for Research and Innovation (GSRI), Ministry of Development), the business (DINTELLO Consulting, Ferro, ICL Group, KENICO, MONDELEZ international, Opix, Piraeus Bank, Symbiolabs Circular Intelligence), the mass media (Business Daily.gr, Epixeiro.gr, Insider.gr, Kathimerini.gr), the civil society (Energizing Greece, HELISS, Minoan Energy) and the academia (Agricultural University of Athens, ATHENA RC, Athens University of Economics and Business, Culturepolis, Hellenic Center of Marine Research, Hellenic Mediterranean University, National and Kapodistrian University of Athens, National Observatory of Athens, University of Aegean, University of Crete, University of Patras, University of West Attica) in Greece.

4. Discussion

5. Conclusions

Implementing the Living Lab on Climate Change presented a dynamic process of collaboration and innovation, which can be both demanding and gratifying. Living Labs are settings in which tangible users engage in active participation to co-develop, evaluate, and authenticate novel concepts, technologies, or services. The process of coordinating a Living Lab frequently encompasses various critical elements.

To begin with, the establishment of a collaborative ecosystem engenders enthusiasm by uniting a multitude of stakeholders, including researchers, industry collaborators, policy analysts, the civil society, and end-users. It can be invigorating to foster an environment that encourages creative interaction and facilitates open communication. On the other hand, managing diverse perspectives and expectations can be difficult. The Living Lab's iterative process and perpetual feedback cycle facilitate swift prototyping and improvement. Observing the concrete results of user participation in the development process of the IntelComp tools can evoke immense gratification. On the contrary, the capacity to navigate unanticipated obstacles and adjust to changing conditions necessitates both flexibility and resilience. One of the greatest challenges that we had to deal with was engaging stakeholders in this process. Understanding the tools from an early stage, diverse interests and competing agendas were some of the barriers that were raised during the PLL and the LL workshops.

However, though this long journey and the LL, we managed to collect feedback and needs from a diverse group of stakeholders, leading to a better understanding of the climate change insights that our society needs today.

Living Labs on CC started early aiming to narrow down the broad topic of climate change. During the Preparatory Living Lab (7 workshops in total), which took place from June 2021 until February 2022, almost 100 representatives from the academia, public and private sector, as well as from NGOs were engaged. In addition, approximately 50 Stakeholders from Greece and EU participated in the Living Lab (4 workshops in total, 2 on Energy and 2 on the Agri-food), which took place from December 2022 until October 2023, and around 60 in the final trainings that were organised during the National Info Day, on 20th of November 2023.

In summary, the Preparatory Living Lab showed that the energy and the Agri-food sector should be the centre of the IntelComp tools, while the Workshops on the Energy sector pinpointed several areas of improvement and expansion, such as the integration of the key messages of the policy documents using KPIs; the specific policies that have been set by the EU; the relation of policy development and technology, industry and R&D; which projects are being funded and at what time; insights regarding employment and future jobs; and dive deeper into the classification of the SDGs and not just in the upper level.

The first sector that was examined during the workshops was the Energy sector. During the two Workshops held in December 2022 and March 2023, stakeholders were introduced to the early stages of the STI Viewer, a tool that was welcomed by every category and that sparked very interesting conversations during the meetings. In the first workshop, Stakeholders had a brief introduction to the tool and were mostly asked to provide feedback on how they would like to see their expectations being materialised. After stating their considerations, discussion was focused on the Energy Transition and how it can take place smoothly and just. In the 2nd Workshop, participants were shown a -then developed- version of the STI Viewer and were asked to elaborate on the usability of the tool and its expansion. After commenting on the importance of the tool, participants asked about different user profiles, highlighted the need to strike a balance between providing a thorough overview of data while crafting a compelling narrative and linking the industrial sector with research. Additional suggestions included the ability to filter data by more criteria (i.e. type of research institution, by country), the ability to create custom visualisations, to integrate other sources to the visualised data, and the ability to download data. In general, concerns were expressed, as expected, regarding the goal towards Sustainable Energy and its effects on society, highlighting its importance and proving that the opinion of communities should be heard carefully during policy making.

During the Workshops on the Agri-food sector, Stakeholders shared their views on the STI Viewer and on what should be done additionally to suit their needs. Among the key remarks were the following: The inclusion of more filters about Climate Zones, Regions, Specific Countries (or even Crops); the commercialisation status of the patents, as well as the investments that they received; and the integration of specific time frames and the possibility to export and share specific results. Stakeholders also exchanged ideas on specific graphs. Indicatively, regarding the scientific collaborations, they would be interested to see the countries/organizations that work on these topics, the technologies that these topics capture, the definitions of these topics, as well as the problems that these solutions that these technologies solve.

Participants also raised concerns that should be taken into account in the STI Participation Portal survey regarding the Agri-food breakdown that should include aspects, such as the chemical industries, emissions, and retail; as well as that policy makers need to map where we stand today, provide motives to farmers (such as financial aid, specific trainings, connection with the innovation and scientific community) for implementing sustainability practices, and to sellers (such as redefining the producer's responsibility) to avoid food loss.

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